

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

Acid Rain Destroying Many Historical Monuments

Dr. Ruchi Purohit

Associate Professor in Botany, Govt. College, Sirohi, Rajasthan, India

ABSTRACT: Acid rain, a byproduct of the large-scale burning of sulfates and nitrates, has been an observed phenomenon since the very earliest years of the industrial revolution in 1872, when English scientist Robert Angus Smith wrote of its corrosive effect on buildings and plants. As large amounts of these chemicals are released into the atmosphere through such processes as the burning of coal, they become bonded with water vapor held in clouds and are subsequently released to the Earth in the form of highly acidic rainfalls. While acid rain only causes indirect damage to living human beings, primarily through its reactions with Volatile Organic Compounds (VOCs) to form ground-level Ozone (smog), it causes tremendous damage to soil fertility, aquatic life, and durable inorganic materials such as stone and metals. Some of the greatest measurable effects of acid rain can be observed on human constructions, particularly old buildings with facades built of corrosion-prone metals such as copper and porous stone such as limestone.

KEYWORDS: acid rain, corrosive, earth, ozone, metals, limestone, human beings, metals

I. INTRODUCTION

Unfortunately, buildings and monuments at most of the world's most important heritage places were not built to withstand such toxic punishment, and as many of these great sites are located in or near burgeoning industrial cities, they have sustained considerable damage. In our modern global economy, as developing countries such as China and India become increasingly industrialized without implementing the stringent pollution controls mostly adopted decades ago by older industrialized nations, many of their greatest cultural treasures are at risk from their own runaway national economic success. These hazards are not, however, limited in any sense to the rapidly-industrializing world; countries such as Australia have also experienced terrible conflicts between cultural preservation and industrial concerns, while the chemical-laden clouds themselves know no borders and have the potential to float over a large area.¹

1. **LESHAN GIANT BUDDHA, MOUNT EMEI (China, Buddhist)**
Towering above the sheer river gorges of China's Sichuan province, Mount Emei, one of the "Four Sacred Buddhist Mountains of China", represents the main seat of Chinese Buddhism.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019



It is home to the country's first Buddhist temple, built in the 1st century C.E., and contains numerous other temples, monasteries and religious shrines, including the 8th century Leshan Giant Buddha. This Tang Dynasty-era masterpiece is the world's largest Buddhist statue, reaching an awe-inspiring 71 meters in height and is 28 meters in width. Carved out of a face of a sandstone cliff facing Mount Emei, the Leshan Giant Buddha is surrounded by spectacularly lush and breathtaking subtropical and subalpine forests, and rests atop the confluence of three major rivers, the Minjiang, Dadu, and Qingyi. This site is a place of invaluable religious, artistic and natural significance.²

The Leshan Buddha has fallen victim to pollution emanating from unbridled development in the region. In this case, the culprit has been determined to be the growing number of coal fired power plants located near the Giant Buddha, specifically, the toxic gases that their smokestacks spew into the air; these eventually return to the earth as acid rain. Over time, the Buddha's nose has turned black and the curls of his hair have begun to fall from his head. The local government has shut down several factories and power plants in close proximity to the Leshan Giant Buddha, which has stopped the blackening of his face from soot; however, acid rain continues to compromise the structural integrity of this masterpiece. The Leshan Giant Buddha, which was designed carefully to survive millennia of floods and earthquakes, is now at high risk of rapid deterioration from the unbridled pace of industrial development in western China.³

2. ACROPOLIS OF ATHENS (Greece, Ancient Greek)

While there are many Acropolises in Greece, it is the Acropolis of Athens that is, without question, the most quintessentially important monument that carries the name; indeed, when historians refer to simply "the Acropolis", it is the one in Athens that is being referenced. Located atop a flat rock rising 150 meters above the city of Athens, its three hectares of standing monuments from the Classic Periclean period (460-430 BCE) include the Parthenon, the Propylea, and the Erechtheum, as well as a few earlier Mycenaean edifices⁴ such as the Cyclopean Circuit Wall that helped to defend the Acropolis from numerous invasions over the centuries. As the foundational center for Golden Age Athens and its way of thought, the Parthenon is widely considered to be the crucible of democracy and Western culture as we know it.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019



In recent decades, as Greece has experienced substantial economic expansion and development, pollutants and heavy vehicle emissions from the booming modern city of Athens have contributed to acid rain in the region. The monumental and sculptural stone of choice for the ancient Greeks, marble, is highly susceptible to heavy surface degradation from even low levels of acid rain. The Parthenon's magnificent marble relief frieze panels, for instance, have been chemically transformed by acid rain into soft gypsum. As details are lost and the chemical transformation soaks deeper into the marble on these vital monuments, pieces of them have begun to crack and fall off, with structural collapse a possibility in the not-so-distant future. Further complicating the situation is the seismically-active nature of the region, as earthquakes would have a far greater effect on marble constructions that have slowly transformed into gypsum than with unaltered marble.⁵

3. TAJ MAHAL (India, Mughal Islam)

Located in Agra, India, the Taj Mahal is a huge mausoleum built between 1631 and 1648 in the Mughal architectural style, combining elements of Turkish, Indian, Persian, and Islamic design. Considered to be the penultimate masterpiece of Islamic architectural art in India, it was built by Shah Jahan for his wife Mumtaz Mahal, and both are interred in it in a simple crypt. The Taj Mahal is India's preeminent tourist destination, attracting between two and four million visitors annually. In an effort to control the deleterious effects of pollution, tourist traffic is not allowed near the site, with most visitors riding in by electric bus from nearby carparks.⁶

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019



This has not, however, slowed down the degradation of the Taj Mahal's marble facades from acid rain generated from local foundries and an oil refinery. The once brilliant-white Taj has been losing its luster, dulling into a sickly pale shade.

4. DAMPIER ROCK ART COMPLEX (Australia, Australian Aboriginal)

The Dampier Archipelago, located in northwestern Australia and stretching into the Indian Ocean from the Burrup Peninsula, is home to a magnificent collection of Aboriginal petroglyphs carved in rock faces and outcroppings. With around a million carvings across 400 square kilometers, these engravings constitute the largest corpus of rock art in the world. Some of the most ancient carvings date to tens of thousands of years into the past, when people first settled Australia, and depict sacred spirits, rituals, and animals – including several that are extinct (Tasmanian Tigers) or are no longer found in the region (Emus).⁷



International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

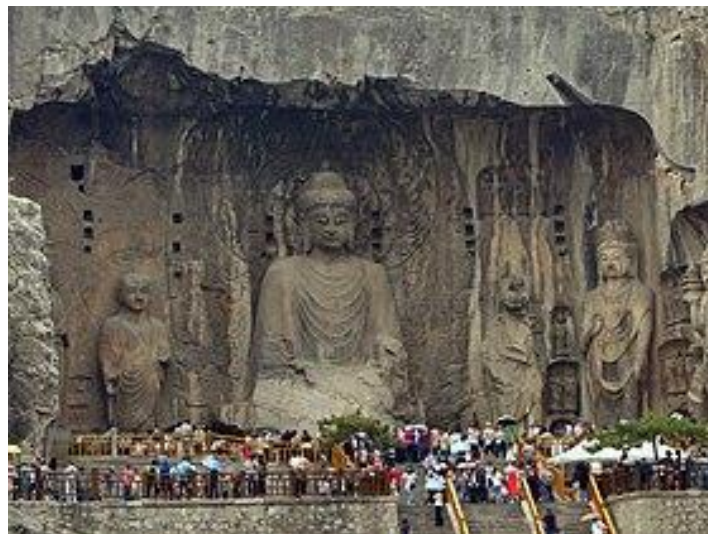
Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

The Burrup Peninsula's rock art sites have been listed as endangered by the National Trust of Australia, but industrial expansion since 1963 across more than 25% of the rock art area has posed severe threats to the site. Much of the heaviest (mining and petrochemical) industry is located immediately adjacent to some of the most sensitive collections of artwork. Acid rain from this has begun to erase many of the carefully, but often shallowly, engraved rock surfaces, and studies by archaeologists and geologists have postulated that most of the rock art will disappear completely by the middle of the 21st century.⁸

5. LONGMEN GROTTOES (China, Buddhist)

The Longmen Grottoes are arguably the most famous ancient sculptural site in China. Located in Henan Province and positioned on two opposing bluffs above the Yi River, most of the artwork is Buddhist in nature and dates to the late Northern Wei and Tang Dynasties (316-907 AD). 2345 niches were carved from the rock, densely worked over the space of approximately a kilometer to the north and south, and they house more than 100,000 statues (also carved from the rock). Accompanying inscriptions bear more than 300,000 Chinese characters and are a treasure trove of historical and linguistic data. The Longmen Grottoes are a masterpiece of Buddhist art and are considered one of the world's most important sculptural sites.⁹



Through the centuries, natural and manmade factors have damaged the niches, sculptures and paintings. Crevices across the rock base are causing instability and have resulted in the collapse of some niches and the destruction of their contents. This process has been greatly accelerated by increased saline sediments resulting from acid rain, a major problem across much of China. Salt deposits have also built up in the niches themselves from slow permeation of acid rain into the rock, which then seeps into the niches through fissures in the rock, severely damaging and rapidly eroding many sculptures and paintings.¹⁰

II. DISCUSSION

India's enduring symbol of love, Taj Mahal, suffered damages in a deadly thunderstorm on Friday, 29th of May. 13 people were killed in 2 districts in Uttar Pradesh due to the thunderstorms.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019



One of the Seven Wonders of the World, Taj Mahal suffered harm to a sandstone railing in the original structure, along with damage to a marble railing and the main gate, as reported through assessment by the Archaeological Survey of India. Taj Mahal has been long known for losing its shine due to pollution. Here are other Indian monuments that have suffered damages in recent history.¹¹

GOLDEN TEMPLE

Air pollution is to blame for dampening the shiny gleam of the iconic Golden Temple, considered as the holiest shrine for the Sikh community. Crop burning exercise by farmers in North India is known for increasing pollution in Delhi, but it also affects the holy Golden Temple.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019



Authorities are trying their best to reduce pollution in the surrounding areas, but if the trend of pollution continues, the expensive process of replacing the gold-plated wall will be the only solution.¹²

LOTUS TEMPLE

It comes as no surprise that the white marbles of Lotus Temple, located in one of the world's most polluted cities, Delhi, is turning grey.



Traffic congestion around the structure and vehicular emissions are to blame for the change in colour. Despite regular maintenance, the Bahá'í temple is expected to turn grey in just a couple of years.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

HAMPI

The Hampi monuments, famous for belonging to the medieval kingdom of Vijaynagar, is a UNESCO World Heritage site in Karnataka.¹³



Its ruins of sculptures and monuments are known to attract visitors from all over the world and is a regular feature in Indian history textbooks. In 2018, a video of young men vandalizing a pillar of the Vishnu Temple went viral. What's surprising is that the damages remained undetected by the Archaeological Survey of India (ASI) and were only discovered after the videos went viral.

CHARMINAR

Acid rain and pollution are to blame for the woes of the Charminar, an iconic monument of the city of Hyderabad.¹⁴



International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

The 400-year-old monument is turning black due to excessive pollution in the surroundings. Noise pollution is producing vibrations that result in the peeling off of the plaster of the monument.

III. RESULTS

When pollutants in the atmosphere, such as nitrogen oxides and sulphur oxides, mix with precipitation and fall as rain, this is known as acid rain. Acid rain affects the soil and vegetation, causes diseases in human beings, and damages buildings. Thus there is an urgent need to adopt measures to control acid rain. Acid rain can be controlled by reducing the amount of sulphur dioxide and oxides of nitrogen released into the atmosphere, switching to cleaner fuels, treating waste gasses, and neutralizing the acids. Acid Rain, as the name implies, is the precipitation of acid in the form of rain in the most basic sense. Acid rain is made up of highly acidic water droplets that form as a result of air pollution, particularly the disproportionate amounts of sulfur and nitrogen produced by cars and manufacturing operations. There are two types of acid deposition: wet and dry. Any type of precipitation that removes acids from the atmosphere and deposits them on the earth's surface is known as a wet deposition. Dry deposition of harmful particles and gasses adheres to the ground through dust and smoke in the absence of precipitation.¹⁵

Measures to Control Acid Rain

Reducing the Amount of Sulphur Dioxide and Oxides of Nitrogen

- Scientists have devised a variety of methods for reducing the quantity of sulphur dioxide generated by coal-fired power plants.
- One alternative is to use coal with lower sulphur content. Another technique is to "wash" the coal in order to remove some sulphur.
- Scrubbers, which remove sulphur dioxide from gasses leaving the smokestack, can be installed at the power plant.
- Because nitrogen oxides are produced during the combustion of coal and other fossil fuels, some power plants are altering their coal-burning processes.²³

Cleaner Cars

- Automobiles and trucks are key polluting sources that generate acid rain.
- While a single car does not emit a lot of pollution, when all of the cars on the road are joined together, it produces a lot of pollution.
- As a result, automakers must limit the number of nitrogen oxides and other pollutants generated by new vehicles.
- A **catalytic converter** is such a type of technology used in automobiles.
- This piece of equipment has been used to minimize the number of nitrogen oxides generated by automobiles for over 20 years.
- Cleaner fuels, such as natural gas, are also available in certain new cars.
- Low-emission automobiles are those that emit fewer pollutants and are therefore better for the environment.¹⁶

Flue Gas Desulphurization

- Flue-gas desulfurization (FGD) is a set of technologies for removing sulphur dioxide (SO₂) from fossil-fuel power plant exhaust flue gasses, as well as other sulphur oxide-producing processes like waste incineration.
- Most FGD systems have two stages: one for removing fly ash and another for removing SO₂.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

- The removal of both fly ash and SO₂ in a single scrubbing vessel has been attempted.
- Thus these systems greatly help in reducing the SO₂ emissions.²²

Liming

- Liming is the process of applying calcium- and magnesium-rich materials, such as marl, chalk, limestone, burnt lime, or hydrated lime, in various forms.
- These elements, in general, react as a base in acid soils and neutralize acidity.
- Consequently, in-stream liming (the addition of fine particles lime or other buffering minerals directly to a stream or river waters) enables immediate acid neutralization and thus an immediate increase in water pH.
- Thus liming can be employed in reducing acid rain.¹⁷

Alternative Energy Source

- Producing energy without the use of fossil fuels is an excellent approach to preventing acid rain.
- People can instead use **renewable energy** sources like solar and wind power.
- Because they produce far less pollution, renewable energy sources aid in the reduction of acid rain.
- These energy sources can also be utilized to generate electricity and power machinery.

Energy Conservation

- The most important step in preventing acid rain is to reduce overall energy consumption.
- This can be accomplished simply by shutting off laptops and televisions that aren't in use while leaving the room.
- The home's heating and cooling system is another significant energy taker.
- This can also be reduced by using them only in need.²¹

Preferring Public & Alternate Transportation Means

- Since automobiles are a major source of acid rain pollution, it is critical to discover other forms of transportation in order to reduce our dependence on fossil fuels.
- You may help reduce motor emissions by taking public transportation, carpooling, biking, or even walking. When at all possible, avoid driving.
- Alternative energy sources Stopping the use of nonrenewable fuels and switching to renewable energy sources like solar, wind, and water energy is a good strategy to reduce acid rain. Alternative energies will become increasingly available to the general people as technology advances. To help the environment, consider solar-powered heating systems and battery-powered autos.¹⁸

IV. CONCLUSIONS

With an ever-increasing global population, more farmers will utilize nitrogen fertilizer in the future to feed people, resulting in an increase in nitric acid production. Leaders are thus debating nitrogen emission management and monitoring standards. Nitrogen emissions have also been monitored differently in different countries. Some believe that the controversy over climate change will hinder progress in tracking emissions. Technology, on the other side also is continually being developed to detect pollution levels such as sulphur dioxide. Even though the actual instrument is hundreds of meters distant, certain technology can detect substances causing acid rain in real-time.^{19,20}

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

REFERENCES

1. US EPA, OW (September 3, 2015). "Drinking Water Regulations and Contaminants". www.epa.gov. Retrieved October 19, 2017.
2. ^ US EPA, OAR (February 9, 2016). "What is Acid Rain?". www.epa.gov. Retrieved October 19, 2017.
3. ^ US EPA, OAR (March 16, 2016). "Effects of Acid Rain". www.epa.gov. Retrieved March 29, 2016.
4. ^ Magaino, S. (January 1, 1997). "Corrosion rate of copper rotating-disk-electrode in simulated acid rain". *Electrochimica Acta*. **42** (3): 377–382. doi:10.1016/S0013-4686(96)00225-3. ISSN 0013-4686. Archived from the original on June 9, 2018. Retrieved April 22, 2018.
5. ^ US EPA: Effects of Acid Rain – Forests Archived July 26, 2008, at the Wayback Machine
6. ^ Markewitz, Daniel; Richter, Daniel D.; Allen, H. Lee; Urrego, J. Byron (1998). "Three Decades of Observed Soil Acidification in the Calhoun Experimental Forest: Has Acid Rain Made a Difference?". *Soil Science Society of America Journal*. **62** (5): 1428–1439. Bibcode:1998SSASJ..62.1428M. doi:10.2136/sssaj1998.03615995006200050040x. ISSN 1435-0661.
7. ^ Effects of Acid Rain – Human Health Archived January 18, 2008, at the Wayback Machine. Epa.gov (June 2, 2006). Retrieved on 2013-02-09.
8. ^ P. Rafferty, John. "What Happened to Acid Rain?". *Encyclopædia Britannica*. Retrieved July 21, 2016.
9. ^ Kjellstrom, Tord; Lodh, Madhumita; McMichael, Tony; Ranmuthugala, Geetha; Shrestha, Rupendra; Kingsland, Sally (2006), Jamison, Dean T.; Breman, Joel G.; Measham, Anthony R.; Alleyne, George (eds.), "Air and Water Pollution: Burden and Strategies for Control", *Disease Control Priorities in Developing Countries* (2nd ed.), World Bank, ISBN 978-0-8213-6179-5, PMID 21250344, archived from the original on August 7, 2018, retrieved April 22, 2018
10. ^ Sisterson, D. L.; Liaw, Y. P. (January 1, 1990). "An evaluation of lightning and corona discharge on thunderstorm air and precipitation chemistry". *Journal of Atmospheric Chemistry*. **10** (1): 83–96. Bibcode:1990JAtC...10...83S. doi:10.1007/BF01980039. ISSN 1573-0662. S2CID 97714446.
11. ^ US EPA, OAR (February 9, 2016). "What is Acid Rain?". www.epa.gov. Retrieved September 13, 2017.
12. ^ Likens, Gene E.; Keene, William C.; Miller, John M.; Galloway, James N. (1987). "Chemistry of precipitation from a remote, terrestrial site in Australia". *Journal of Geophysical Research*. **92** (D11): 13299. Bibcode:1987JGR....92i13299L. doi:10.1029/JD092iD11p13299. Archived from the original on February 21, 2017. Retrieved August 25, 2018.
13. ^ Glossary, United States: NASA Earth Observatory, acid rain, archived from the original on December 13, 2011, retrieved February 15, 2013
14. ^ E. S. de Beer, ed. *The Diary of John Evelyn, III*, 1955 (September 19, 1667) p. 495.
15. ^ Weathers, K. C. and Likens, G. E. (2006). "Acid rain", pp. 1549–1561 in: W. N. Rom and S. Markowitz (eds.). *Environmental and Occupational Medicine*. Lippincott-Raven Publ., Philadelphia. Fourth Edition, ISBN 0-7817-6299-5.
16. ^ Seinfeld, John H.; Pandis, Spyros N (1998). *Atmospheric Chemistry and Physics — From Air Pollution to Climate Change*. John Wiley and Sons, Inc. ISBN 978-0-471-17816-3
17. ^ Acid Rain in New England, A Brief History Archived September 25, 2010, at the Wayback Machine. Epa.gov. Retrieved on February 9, 2013.
18. ^ Likens, G. E.; Bormann, F. H.; Johnson, N. M. (1972). "Acid rain". *Environment*. **14** (2): 33–40. doi:10.1080/00139157.1972.9933001.
19. ^ Brøgger, Waldemar Christofer (1881). "Note on a contaminated snowfall under the heading Mindre meddelelser (Short communications)". *Naturen*. **5**: 47.
20. ^ Ottar, Brynjulf (1976). Dochinger, Leon; Seliga, Thomas (eds.). "Organization of long-range transport of air pollution monitoring in Europe". *Proceedings of the First International Symposium on Acid Precipitation and the Forest Ecosystem*, May 12–15, 1975, Columbus, Ohio. Upper Darby, PA: USDA Forest Service. **6** (2–4):

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

105. Bibcode:1976WASP....6..219O. doi:10.1007/BF00182866. S2CID 97680751. Large amounts of sulphuric acid can be transported over distances up to a few thousand kilometers.
21. ^ Odén, Svante (1968). "The Acidification of Air and Precipitation and its Consequences for the Natural Environment". Ecology Committee, Bul. 1. Nat. Sci. Res. Council of Sweden. Retrieved December 5, 2017.
22. ^ Satake, Kenichi, ed. (December 6, 2012). Acid Rain 2000 Proceedings from the 6th International Conference on Acidic Deposition: Looking Back to the Past and Thinking of the Future, Tsukuba, Japan, 10–16 December 2000. Netherlands: Springer. p. 20. ISBN 9789400708105. Retrieved December 5, 2017. Extensive scientific attention to acid deposition arguably began in 1968 when Svante Odén published his landmark paper on acidification (Oden, 1968).
23. ^ Hannigan, John A. (1995). Environmental Sociology: A Social Constructionist Perspective. Routledge. p. 130. ISBN 9780415112543. Retrieved December 5, 2017. Of more immediate impact was the work of Svante Odén, a Swedish soil scientist. Odén, now widely regarded as the 'father of acid rain studies' (Park, 1987:6) not only found that the acidity levels of precipitation were increasing in Scandinavia but he was the first to definitively link source and receptor areas.